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their formation, and made with such care, must have been designed for some important service, but even those of the comparatively soft talcose rock have as sharp and apparently unused edges as if just made, the polished groove and edge often not showing even a scratch or notch. Some of them are worn, especially some of the smaller specimens, but most are not. Another noticeable fact, which perhaps might be less so in a larger collection, is that each specimen has certain peculiarities of its own, so that it is quite difficult to find duplicates, though they do sometimes occur, but each specimen seems to have been made according to the present fancy of the maker, and this appears to have varied somewhat as each new specimen was undertaken. This variety in form, size and material indicates that the gouge was not an implement designed for a single, limited use, but that, whether we can ascertain the use of the various kinds or not, their uses were as varied as their form and material. Gouge-like implements have been figured as skin dressers by some authors, and this, it seems to me, suggests better than anything else the probable explanation of the character of these implements. If used in cleaning adhering bits of fat or muscle from the skins so generally in use among the aborigines, the edge would remain unworn for a long time, even if the implement were made of no very hard material. It may not improbably be true that some were used in excavating the charred portions of a log selected for a canoe, but it seems more probable that most were used, in one way or another, in the processes of preparing skins for clothing or for whatever other purposes the skins may have been needed.

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LARVAL HABITS OF BEE-FLIES.¹

BY C. V. RILEY.

THE bee-flies (Bombyliidæ) are a family of Diptera that have a rapid, darting flight and hover over flowers, from which they extract nectar by means of a long proboscis which is a characteristic of most of the genera. They derive their popular name of bee-flies, or humble-bee flies, from their general resemblance to bees, due to the hairiness of the body, and enhanced by

¹ Adapted from the Second Report of the U. S. Entomological Commission, to which the publishers are indebted for permission to have impressions of the plate made at their expense.

the humming which they produce in flight. Nothing had been published of their larval habits in this country till last year, though an undetermined larva, at first supposed to be Hymenopterous, but which subsequently proved to be that of *Systoechus*, was figured in the writer's ninth report on the insects of Missouri (1877), and copied in his "Locust Plague in the United States," and into the First Report of the U. S. Entomological Commission.

In October, 1879, we obtained from a lot of larvæ sent us by Mr. G. M. Dodge, of Glencoe, Neb., a single pupa which agrees with those of *Systoechus oreas* O. S.¹ presently to be described, but which, as Baron Osten Sacken writes us, is probably that of *S. vulgaris*, a common species in the Western States, east of the mountains.

During the past two years we have been in correspondence with Professor J. G. Lemmon, of Sierra Valley, Cal., who has kindly sent us many specimens of locusts occurring there, and especially the eggs and early stages of *Cannula pellucida*.

Among such eggs these bee-fly larvæ were, if anything, more common than we had found them among the eggs of the destructive locust, *Caloptenus spretus*, east of the mountains. We here quote one letter in illustration:

"By this mail I dispatch another cigar box filled, this time with sods containing eggs of the terrible locust that for three years past has devastated Sierra Valley; also the large, fat, white larva that lately made its appearance as a voracious feeder upon locust eggs. We don't know certainly what this larva becomes, but at a venture he is hailed with great joy.

"The ground that was first filled with locust eggs by the *Edipoda atrox*, by the end of September looked as if scattered with loose shells, so thorough was the work of destruction.

"A few of them were detected in among the eggs in April, but not generally until August. One individual seems to empty several egg cases before retiring from the feast and coiling himself up in a case which he has emptied, or in a nidus of his own make."—[J. G. Lemmon, in letter to C. V. Riley, October 12, 1879.

During 1878 and 1879 we failed to rear any of them to the perfect state, but on June 20 of the present year, 1880, we obtained from these California larvæ the first fly. This proved to be a male of *Triodites mus* O. S.,² as kindly identified for us by Mr. S. W. Williston, of New Haven. We have, during the sum-

¹ Western Diptera, p. 254; Bull. Hayden's Geol. and Geog. Survey, III, No. 2.

² *Ibid.* p. 246.

mer reared many additional specimens of this species, and also of the *Systæchus oreas* O. S., already alluded to. Professor Lemmon and his brother, Mr. W. C. Lemmon, have also succeeded in obtaining the mature flies, and have observed this *Systæchus* abundantly buzzing about over the ground in which the locust eggs were laid, as the following extracts from the correspondence of these gentlemen will show:

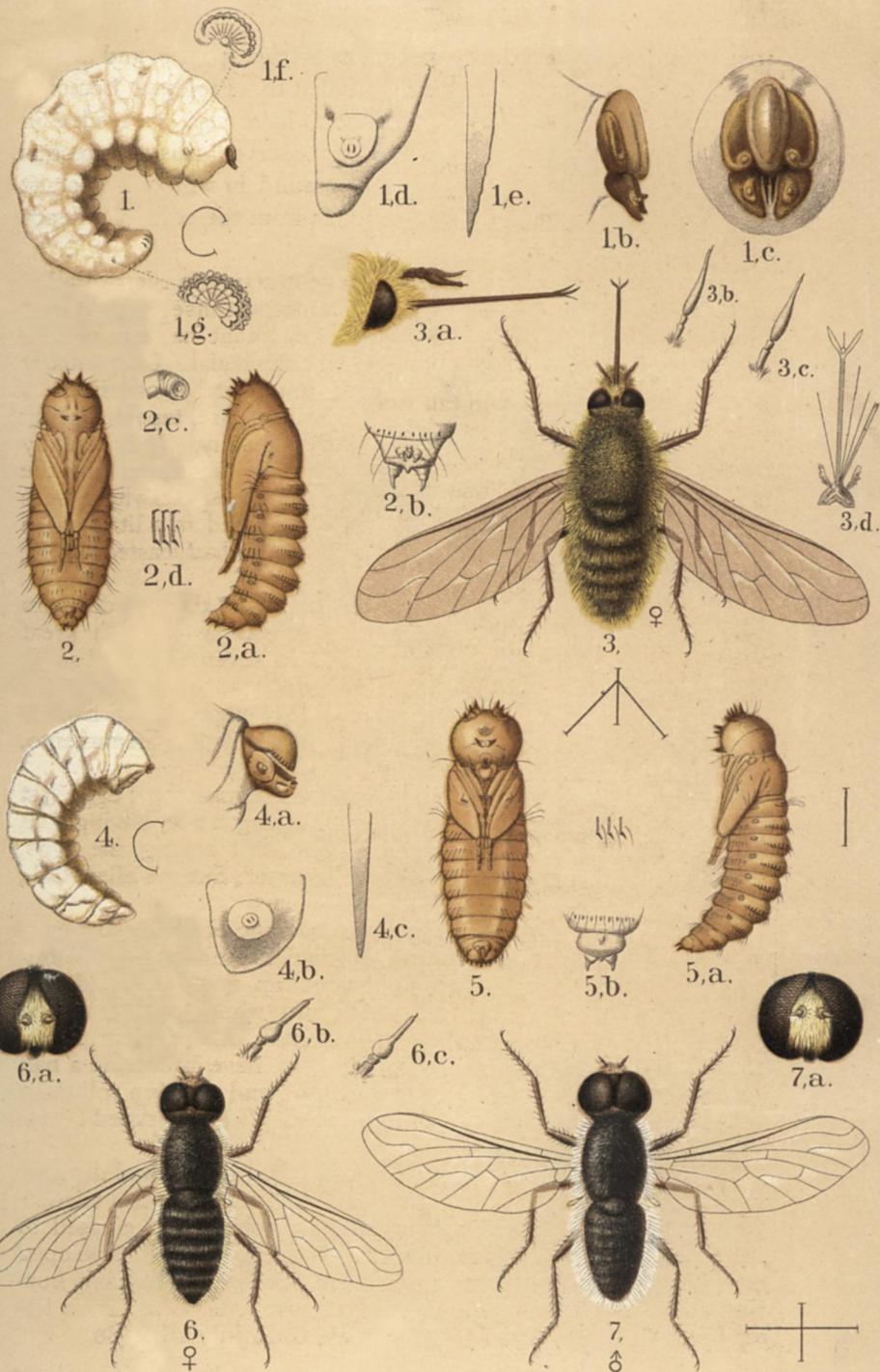
"An enemy which has proved very destructive in Sierra Valley and vicinity is the larva of, as yet, an unknown insect. It is first observed as a large yellowish-white grub about half an inch or even three-fourths of an inch long when extended, it being usually curved so that the head and tail nearly touch. It is one-sixth to one-fifth of an inch thick just back of the head, and tapers slightly towards the tail, also flattened slightly dorsally. It is usually found in a case of locust eggs which it has devoured, pushing the empty shells aside, and at last occupying the space where were twenty-one to thirty-six eggs. Often it is found in a little space below a number of emptied cases, as though it had feasted off the contents of several nests.

"The grub was first noticed last April 20, in the egg deposits near Loyalton. This fall, September 7, it was detected in great quantity near Sierraville, and afterwards in several infested spots of the valley. A handful of such soil will generally display ten to twenty cases of locust eggs, more or less emptied, and half as many of the fine, fat grubs."—[J. G. Lemmon in the Sacramento, Cal., *Weekly Record-Union*, November 29, 1879.

"The white grubs ate out and destroyed thousands of eggs last fall, but, to all appearance, have eaten nothing since, having lain dormant all winter, and being now found still among the eggs, which are fast hatching out."—[W. C. Lemmon, Sierra Valley, Cal., June 13, 1880.

"I send you by this mail another package of the locust-egg-eating grubs, some of which you will find more developed. My brother, Professor J. G. Lemmon, came up from Oakland day before yesterday to spend a few days, and while looking at the grubs that I had gathered for you yesterday, one of them developed into the humble-bee fly which you have bred, and a half dozen specimens of which I have caught and envelop rolled up in paper."—[W. C. Lemmon in letter to C. V. Riley, dated Sierra Valley, Cal., July 18, 1880.

"Happening home on a hurried visit, I find locusts and destruction all around—a sad, sad sight! Find my brother has tried to keep you posted up with specimens and notes. Am pleased to see a solution of the "big white grub" question. He developed into a species of fly, hosts of which are now seen in midday, buzzing about among the locusts."—[Professor J. G. Lemmon in letter to C. V. Riley, dated Sierra Valley, Cal., July 18, 1880.



This habit in the larvæ of Bombyliids of preying on locust eggs has not before been suspected, and in this connection we will review what has hitherto been known of their habits.

Professor J. O. Westwood has given, in the Transactions of the Entomological Society of London, 1876, pp. 497, 498, the following summary of observations upon the larval habits of Bombylii:

"Thanks to the researches of previous observers, the economy and transformations of the Bombylii are now satisfactorily known to entomologists. Latreille rightly considered that the Bombylii, like Anthrax, were parasites, contrary to the opinion of Zetterstedt that the larvæ feed on the roots of plants (Ins. Lapp., p. 510). The pupa of *Bom. major* was first figured by M. Imhoff, in the *Isis* for 1834, having been found by him in a situation which he had previously noticed to be frequented by *Andrena humilis* (Vol. 1834 p. 536, pl. xii). In my Introduction (Vol. II, p. 538, 1840) I published a figure of the same pupa from a specimen discovered by M. C. Pickering in a sandy gravel-pit at Coombe Wood, on the 28th of March, from which the imago was produced in a few days. The pupa is very similar to those of the species of Anthrax, which are known to be parasites, having the front and under side of the head armed with strong spines, and the dorsal segments of the abdomen furnished with transverse rows of strong reflexed hooklets. In 1852, M. H. Lucas published the description of a new Algerine species of the genus, *Bomb. boghariesis*, in the Annals of the French Entomological Society, 2d ser., Vol. x, p. 11, pl. 1, No. 11, which he had reared from a pupa found under a stone in a damp, sandy situation, and, contrary to the opinion of Latreille, he expressed himself thus: 'Je suis porté à croire que les larves qui composent ce genre ne sont pas parasites, comme le supposent Latreille et beaucoup d'autres Entomologistes, mais qu'elles vivent au contraire isolément dans la terre,—opinion, au reste, qui avait déjà été émise, mais avec doute, par M. Macquart, et que mon observation vient confirmer.'

"In 1858, the real history of the Bombylius was discovered by the veteran Léon Dufour, who in the spring found various exuviae of the pupa of *B. major* sticking out of the ground, together with the newly-hatched insect, in places much frequented by various Andrenidæ, especially in the autumn, by digging on the spot, to find the larva, 'au milieu des déblais, où gisaient par-ci par-là des coques de Colletes' (Ann. Soc. Ent. France, 3d ser., tom. vi, p. 505, pl. 13, Fig. 111, and details). The larva is elongated, apod and fleshy, and of a white color. The preceding observations clearly prove that the larvæ of the Bombylii are parasites in the nests of other insects, in the manner of the cuckoo among birds."

The last statement of Professor Westwood is, however, not justified by Dufour's observations. On the contrary, Dufour ex-

pressly states that he did not observe upon what the larva fed; the inference which he draws is based upon the analogy of *Anthrax*, and he inferred that it was upon the larvæ of *Colletes* that the grub fed; quite a different thing from being a cuckoo in the nest and feeding only upon the pollen. There is, in Dufour's paper, no evidence to prove that the *Bombylius* larva was found in the cocoons, or even in the cells of the bee; he states, in fact, that he failed to find it there, but found it among the clearings (*déblais*) which he had made in digging out the nests. Professor Westwood himself found numbers of *Bombylius medius* flying in association with a species of *Andrena* in the unpaved Forum Triangulare of Pompeii, and found at the same spot the pupa-shell of the fly protruding from the ground.

As early as 1838, Macleay (Ann. N. H., Vol. II, p. 12), stated that he had "discovered that the larvæ of those tropical *Bombylii* which have such a bee-like form live on the larvæ of the bees they so strikingly represent," although he gives no particulars of his discovery.

Dr. Morelet, in 1854, recorded the fact that he had obtained a *Bombylius* from a nest of *Halictus succinctus* (Bull. Soc. Ent. de France, 1854, p. xxiv).

Dr. Packard ("Guide," &c., p. 397) states that "a species [of *Bombylius*] is known in England to lay its eggs at the opening of the holes of *Andrena*, whose larvæ and pupæ are devoured by the larvæ of the fly." But no authority is given for this statement.

Messrs. Allen and Underhill, in *Science Gossip*, 1875, p. 80, express their belief that the *Bombylii* are parasitic on humble-bees. In the volume for 1876, p. 171, they say (speaking of *Sitaris*):

"In relation to the larva of this beetle, we would remark that this year we have found it clinging to *Bombylii*. This is 'circumstantial evidence' that *Bombylii* frequent the nests of *Anthrophora* to lay their eggs, since *Sitaris* itself, from its manner of life, cannot be the parasite of a fly, but only of a bee."

Schmidt-Goebel, as Baron Osten Sacken has pointed out,¹ reared one of the smaller unicolorous *Bombylii* from among the pupæ of *Colletes fodiens* (Stettiner Ent. Zeit., 1876, p. 393), which so infested a clayey bank that he could not place his thumb anywhere without discovering an entrance to a burrow.

Finally, Dr. T. Algernon Chapman (*Ent. Monthly Mag.*, Feb.,

¹ *Entom. Monthly Mag.*, Feb., 1881, p. 206.

1878, p. 196), as shown in the February number of the NATURALIST, gives abundant proof of the parasitism of *Bombylius major* on *Andrena labialis*.

From these records of European observations, it is sufficiently certain that some of the Bombyliids develop in the cells of mason and burrowing bees, but whether as true parasites on the larvæ of the bees or as partial parasites on the pollen-paste stored up by the same, as in the case of the larvæ of some of the Meloids, does not seem to have been observed. The former is most probably the case, however, for it has been clearly ascertained, and is well known, that Anthrax feeds in the larva state upon the young of certain bees. The larva of the Anthrax before attaining its own full growth and before destroying its host must await the full growth of the latter, as it has, by several observers, been bred from the cocoons of the insects upon which it was parasitic.

In his "Western Diptera" (*l. c. p. 243*) Baron Osten Sacken gives references to the published account of the parasitism of the Anthracid genus *Argyramæba* within the nests of *Cemonus* and *Chalicidoma*; cites Schiner's statement that the larvæ live parasitically in pupæ of Lepidoptera, and records the breeding of *A. cephush* and *A. fur* from the nest of a Texan mud-wasp, which he referred, with a question, to *Pelopœus*, but which, as we have ascertained from an examination of the mud tubes which are deposited in the Cambridge Museum of Comparative Zoölogy, belong to *Trypoxylon*. We have similar cells from Texas and other parts of the South. They differ from those of *Pelopœus* in being wider, ribbed on the upper surface, and fastened not only side by side, but in long tubes, end to end. The *Pelopœus* spins a thin, yielding, semitransparent, elongate cocoon of a golden-brown color, with more or less loose silk around it, and the tail end thickened and docked; the *Trypoxylon* spins a tougher, thicker, more solid and smooth cocoon of a dull, dark-brown color, generally about half as long as the other (but varying greatly in size), and with the head-end often expanding into a flange.

We have reared what is very near to and probably identical with *Argyramæba fur* from larvæ that had preyed on *Trypoxylon albitarse* which had made use of the mud cells of *Pelopœus lunatus*, or the common mud-dab, in Texas; also from the same

wasp that had made use of the burrows of a bee (*Anthophora abrupta* Say). The larva of *Argyramoeba* has very much the same appearance as that of *Systoechus* and *Triodites*, and the pupa is distinguished from the pupa of this last (Pl. vi, Figs. 5, 5 a), principally by its longer and more numerous hairs, longer anal spines, and more conspicuous spiracles.

Systropus also, in the larva state, preys on the larva of *Limacodes*, as has been observed by Walsh (Proc. Bost. Soc. N. H. ix, 300), and by Westwood (Trans. London Ent. Soc., 1876, p. 571), killing its victim only after the latter has formed its tough cocoon.

With these general remarks, we will now give a more full and descriptive account of the two bee-flies which, by rearing from the larva, we know to have this locust-egg-feeding habit. Our plate illustrates the insects as well as can be done in color printing, but the enlarged heads of the larva should be somewhat darker and less yellow.

SYSTOECHUS OREAS.—The character of the eggs and the manner in which they are laid have not yet been observed. The larva (Pl. vi, Fig. 1) is found in the locust egg-pods, or near them, of different sizes, during most of the year. These larvæ begin to transform to the pupa state early in the summer, and the pupa (Pl. vi, Fig. 2) pushes itself half way out of the ground in order to disclose the fly. These flies continue to issue during the summer months. As a rule, but one year is required for full development, but there is, in this respect, great irregularity, and the same tendency to retardation which we have called attention to in the case of the blister-beetles.¹ We have had quite a number of the larvæ remain over unchanged till the second year, and all that we have said as to the philosophy of this retardation in the one case applies in the other.² We are inclined to think that future obser-

¹ *Am. Entomologist*, III, 196.

² This irregularity in the development of individuals is noticeable in many insects that are parasitic, and whose mode of life is precarious. In the case of our blister-beetles, depending as they do on locust eggs, and especially in the case of those which feed particularly on the eggs of migratory species, it is not difficult to perceive how this trait may prove serviceable to the species possessing it. Migratory locusts occur in immense numbers, in some particular part of the country, at irregular intervals, and there are periods or years of absolute immunity from their presence in the same regions. The young blister-beetles that hatch the year following the advent of the locusts in immense numbers may frequently find few or no locust eggs upon which to prey, and the great bulk of them would, as a consequence, perish; while the young from such exceptional individuals as should not develop till two, three, or

vation will show that there is a still further parallel, in that the newly-hatched larvæ of the bee-flies are much more active than the later stages, and somewhat different in structure.

The three later stages of the insect may be characterized as follows:

Larva (Pl. vi, Fig. 1).—We quote herewith our former description:

“Average length, 0.50 inch. Body curved, glabrous, tapering posteriorly, swollen anteriorly. Color opaque whitish, with translucent yellowish mottlings, and some venous marks at sutures, especially along medio-dorsum. Sutures deep. A lateral row of swellings. Head small, flattened, dark brown, in five pieces, consisting above of a frontal ovoid piece and two lateral pieces of somewhat similar form, and each bearing near tip a minute, two-jointed palpus; beneath of two broad, subtriangular jaws, having forward and lateral motion, and each, also, bearing near the center, in a depression, a two-jointed feeler. A spiracle each side in a fold between joints 2 and 3, and another on each side of the penultimate joint, 12. None otherwise perceptible.”

With additional material we have been enabled to examine more fully the structure of the head. Underneath the median elevated piece which may represent the labrum, we find two stout spines (Pl. vi, Fig. 1 *e*), faintly notched on the outer edge, which are doubtless the mandibles, and correspond to the two dark lance-like mandibles of other Dipterous larvæ, for they are retractile and run back into the thoracic joints, and remain after the other trophi are detached. The pair of feelers upon the upper lateral pieces, which seem to have no motion, might then represent the antennæ, and the two lower jaws the maxillæ with their palpi, while the labium is shown in a chitinous point visible only when the larva extends and raises the other parts. A peculiarity in the movement of the maxillæ or the lower pair of horny pieces is worthy of note. They move in alternation with one another in the forward and backward, *i. e.*, up and down, motion. The palpus of these lower pieces when viewed from above is, as represented in the figure (Pl. vi, Fig. 1 *d*), circular, with two dark marks indicating minute appendages.

When the larva is fresh and plump it shows the greater swelling of the thoracic joints and the translucent mottlings mentioned

more years after a locust invasion might stand a much better chance of finding appropriate food, and of thus perpetuating the species. In this case and in most other cases of retarded development with which we are familiar, the exceptional retardation may and does become a benefit to the species, enabling it to bridge over periods of adversity. And we can see how, by the preservation of such favored individuals, the habit of irregular development may have become fixed in the species as a consequence of surrounding conditions and circumstances which render it advantageous.

above. Toward the period of pupation, it becomes more opaque and more contracted.¹

Pupa (Pl. vi, Fig. 2).—Average length 8.5 mm. Color honey-yellow, but varying with age, the head and thorax assuming a dark color with maturity. Head narrow, with two sets of three stout, dark spines on the top, all on a common prominence, the two lower ones of each set connected at base; a pair of smaller frontal spines near the base of proboscis, which is protuberant and laid along the breast, extending to near the tips of the wings; the face with two parallel depressions running from between the triple tubercles ending in two fossæ above the frontal spines; two basal, medio-dorsal tubercles. *Thorax* unarmed, the prothoracic spiracle very large and raised on a curved tubercle; mesothoracic spiracle on a swelling at base of wings; front tibiæ stout and curved; front tarsi reaching to tips of wings; middle tarsi to abdominal joint beyond, and hind tarsi to third abdominal joint beyond. *Abdomen* curved, with the ninth joint very small; across the middle, dorsally, each joint has a series of parallel, longitudinal, narrow, chitinous plates having at each extremity a spine, the posterior one stoutest; both plates and spines diminishing laterally, gradually aborted on the extreme basal and posterior joints, and replaced on the small ninth joint by a group of four converging and truncate tubercles; two stouter anal spines on the subjoint and a ventral lobe with two short, obscurely articulate processes; each abdominal joint with a circle of hairs, those on lateral ridge stoutest and one-third the width of abdomen in length; eight pair of abdominal spiracles (making ten with those on thorax), the first and last pairs rather difficult of detection.

TRIODITES MUS.—The habits of this insect in the larva state are precisely like those of the preceding:

Larva (Pl. vi, Fig. 4).—So greatly resembling that of the *Systoechus* that it is well nigh impossible to separate the two with certainty. The head parts are somewhat broader, shorter and less flattened, the maxillæ more blunt, the labrum paler, and the mandibles sharper and with a smoother outer edge. The thoracic joints bulge less beneath and the thoracic spiracle is more sunken and less conspicuous.

Pupa (Pl. vi, Fig. 5).—Easily distinguished from that of *Systoechus* in the broader and more bulbous head; in the two sets of three stout spines at top being well separated; in the frontal pair be-

¹ So far as we can ascertain, there has hitherto been published no recognizable figure of the Bombyliid larva. Dufour, in his articles above alluded to, describes that of *Bombylius major* very indifferently, and gives a dorsal view which shows little or no relation to the larva here described, while his description and figure of the mouth parts fail to indicate the different pieces we have observed in our larvæ. Yet in general form and structure the true *Bombylius* larva agrees very closely with those here described, as we know from Dr. Chapman's description.

ing stouter, each with a conspicuous bristle externally; in having a single spine or tooth above these, and another much stouter, erect, recurved spine, bidentate at tip, below them or at base of tongue, which is here represented by a cordate lobe. There is a spine on the front anterior border of each wing; the legs are all shorter; the prothoracic spiracles less conspicuous; the hairs on abdominal joints shorter; the transverse dorsal teeth smaller and in single row; the basal abdominal joint without spines, but with long stout hairs and the dorsal tubercles of abdominal joints nine replaced by a single spine.

EXPLANATION OF PLATE VI.

(Natural sizes indicated in hair-line.)

FIG. 1.—Larva of *Systaechus oreas*, from the side; 1 *b*, head from side, still further enlarged; 1 *c*, same from front; 1 *d*, left maxilla; 1 *e*, left mandible; 1 *f*, mesothoracic spiracle; 1 *g*, pre-anal spiracle.

FIG. 2.—Pupa of *Systaechus oreas*, ventral view; 2 *a*, same, side view; 2 *b*, dorsal part of anal end; 2 *c*, prothoracic spiracle; 2 *d*, form of dorsal horny plates and spines on the abdomen.

FIG. 3.—*Systaechus oreas*, ♀; 3 *a*, head of same from side; 3 *b*, antenna of same from above; 3 *c*, antenna of same from side; 3 *d*, mouth parts separated.

FIG. 4.—Larva of *Triodites mus* as it appears when contracted prior to pupation; 4 *a*, head from side; 4 *b*, left maxilla; 4 *c*, left mandible.

FIG. 5.—Pupa of *Triodites mus*, ventral view; 5 *a*, same, side view; 5 *b*, dorsal view of anal parts; 5 *c*, form of dorsal plates and spines on abdomen.

FIG. 6.—*Triodites mus*, ♀; 6 *a*, her head, front view; 6 *b*, her right antenna from above; 6 *c*, right antenna from side.

FIG. 7.—*Triodites mus*, ♂; 7 *a*, his head, front view.

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LATE EXPLORATIONS IN THE GABOON.¹

BY HUGO VON KOPPENFELS.

TOWARDS the end of last year I again had the good luck to kill an almost full-grown gorilla, whose length was 1.75 meters, and the width of the shoulders 0.89 meters. This gorilla, and a young female, should, by this time, be in possession of Dr. V. von Kraus, Stuttgart. I, by chance, shot the male gorilla in the vicinity of my stopping place on the Eliva-Comi (an inland lake), so that I was able to take a very good cast of it. I hope to be able to take a cast of the next animal I shall kill, but I cannot predict at what time and place I shall get a full-grown male gorilla, and whether the circumstances will allow me to take a cast of him.

¹ From a letter to Mr. H. A. Ward, Rochester, N. Y.